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Estimation of rain induced Specific attenuation

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Abstract : ***This paper describes research on Specific attenuation on a terrestrial microwave communications link set up at Nawandgi-Wadi (Karnataka State), India, which has reported signal failure for a number of times under rainy conditions, especially during July to September, each year. The clear air and rainy climatic data has been secured from India Meteorological Department, Hyderabad for a comparative analysis with the live data of rainfall recorded with the aid of two tipping bucket rain gauges, and a disdrometer. A simple model of interpretation of specific attenuation has been utilized with simple formulae to suit the purpose of estimating the rain-induced specific attenuation at the location of the link. The results of this experimentation are in agreement with the disdrometer observations and the data collected through experiment tallies with the Micro Rain Recorded (MRR) data secured from the ISRO-operated-MRR rainfall data secured. The model used in the experimentation, it is hoped, would enable further research in to the aspects of specific attenuation of terrestrial microwave links in different Terrestrial locations of interest.***

Keywords: Rain Drop Size Distribution (RDSD), 0^0C isotherm height (Hi), Disdrometer, power law, specific attenuation. Sky-noise temperature

I.Introduction

Propagation of millimetre wavelengths through atmosphere causes serious effects on propagation. The loss of propagating signal over earth-space path relative to the free space losses at frequencies above 10 GHz is the sum of different contributions like absorption by atmospheric gases, absorption, scattering and depolarization by rain. Rain is the most serious form of hydrometers which, because of its high dielectric constant, produces large displacement current and hence absorption.

The growing demand for terrestrial and satellite communications has made the bands below 18 GHz over-crowded and led to switching over to higher frequency bands above about 20 GHz **[1]**. The use of higher frequency bands for communication systems is necessary for higher channel capacities **[2]**. Terrific increase in radio traffic in terrestrial and satellite communication links in satellite remote sensing demands a careful investigation and research for higher frequencies which may be used under tropical conditions in India. The radio frequencies above 20 GHz or millimetre waves in general, due to inherent advantages have a number of applications. The reliability of such a system may be severely degraded due to rain fading.

As such, knowledge of rainfall rate & rain-induced attenuation at the frequency of operation is necessary to design a reliable communication system at a particular location. Rainfall rate and rain attenuation data are also desired in many important applications including radio link systems, radar systems and remote sensing **[3]**. The current prediction method of ITU-R uses physical rain height as one of the parameters in the estimation of rain fade on earth to space path but overestimates the rain attenuation when applied to tropical zones. The method is based on the data collected in temperate climates and assumes the mean rain height related to the height of 0°c isotherm height **[4]**. Application of this method to tropical region gave unsatisfactory results and led to the concept of effective rain height. The non-uniform horizontal structure is accounted for, by using rain rate reduction factor to convert the physical path length to an effective path length. This simple vertical structure assumes that rainfall is uniform from the ground to the "rain height" ***Hr***. The effective rain height and attenuation can be obtained from the analysis of the data on sky noise temperature and point rainfall intensity. In view of this, it appears that the rain height in tropical regions cannot be easily related to the *freezing height (0°**c** isotherm height).* It has not yet been possible to find a meteorological parameter to determine the effective rain height accurately.

II.The Present Experiment

Rain induced attenuation over a terrestrial link operating at 28.75 GHz was measured during 1 July 2009 to 30 September 2010 at Wadi, in the Nawandgi-Wadi (Kanataka) microwave link set up for communication purposes. Radiometric measurements were carried out using zenith looking radiometer at 20 GHz. The basic design of radiometer has been realized in conventional Dicke configuration in super-heterodyne mode. It consists of 24″ vertically polarized front fed parabolic antenna. The signal intercepted by the antenna was fed to one of the four ports of the manual switch. The radiometer was calibrated regularly by using hot reference source at 373^0k and cold load

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reference source (liquid nitrogen) at 77.4^{o}k. The radiometer with antenna was housed in an air-conditioned hub with an acrylic sheet window in front of the antenna.

The antenna beam was directed horizontally towards plain reflector, which was kept outside the hub at 36^o elevation angle. The sensitivity of the radiometer was typically around 35mv/^{o}k in the linear region. The sky noise temperature data recorded was converted to the attenuation values and was further analyzed to estimate the effective rain height at various rain rates for the prediction of slant path attenuation. The point rainfall intensity was measured with tipping bucket rain gauge, which co-located near the radiometric set up.

III.Analysis & Results

The experimental data were collected during rains on round-the-clock basis. Data on rainfall rate and raindrop size collected using co-located rain gauges and disdrometer have been analyzed for annual rain rate (R) statistics and rain drop size distribution (RDSD) respectively. Point rain rate distribution is an important parameter to estimate attenuation exceedence. Radiometric data, using zenith looking radiometer were collected to predict zenith attenuation statistics and effective rain height (RH_{eff}).

Rain Rate Statistics

Tipping bucket rain gauge has been employed to measure point rainfall rate. The rain gauge uses a 12-inch diameter orifice and a tipping bucket mechanism coupled to a mercury switch. The buckets are capacitated to make one tip for each 0.01 inch of rainfall. As one-bucket fills and tips, the second bucket starts collecting water. At the time of tip a magnet moves and momentarily closes the mercury switch that is connected to an event marker of the strip line chart recorder where each event is recorded.

The rain rate (mm/hr) at a particular instant is calculated, by measuring the distance between the two tips, as follow:

$$R\ (mm/hr) = (0.254 * x)/ d \quad (1)$$

where, d is the distance in mm, between the two tips; and x is the speed of the chart in mm/hr**.** The point rainfall data for the winter and monsoon seasons for the year 2009-10 have been analyzed for the cumulative rain statistics for the whole year. The Cumulative distribution of rain rate derived from measured data over Wadi (Karnataka) is shown in **Figure. (1)**.

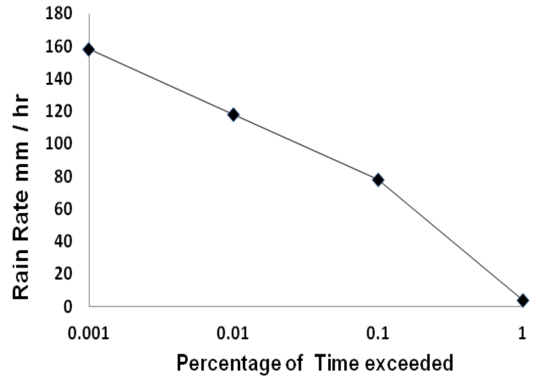

FIGURE .1. CUMULATIVE DISTRIBUTION OF RAIN RATE EXCEEDENCE

Rain Induced Specific Attenuation

Specific attenuation, **α**(db/km) is a fundamental quantity in the calculation of rain attenuation for terrestrial and space to earth path and can be calculated using raindrop size distribution (RDSD). Earlier observations led to the following relation between specific attenuation α (dB/km) and rain fall rate R (mm/hr) as

$$\alpha = a R^{b}\ dB/km \quad (2)$$

Values of the co-efficient ***a*** and ***b*** depend upon frequency, rain temperature & rain drop size distribution. In the present study Medhurst technique has been adopted for the evaluation of specific attenuation based on rain drop size data collected by disdrometer. An empirical relation obtained from the regression analysis over specific attenuation values calculated at various rain rates at 20 GHz & 30 GHz. The specific attenuation at 20 GHz has resulted in the following model**.**

$$\alpha 20 = 0.071R\ 1.115 \quad (3)$$

Based on the experimental model, the specific attenuation values at 20 GHz have been evaluated for different rain rates and compared with those based on ITU-R and MP- RDSD quoted by Olsen et-al **[5]**. It is observed that specific attenuation for the present location is higher than that predicted by other models**.**

IV. Conclusions

A simple model of interpretation of specific attenuation has been utilized with simple formulae to suit the purpose of estimating the rain-induced specific attenuation at the location of the link .From the analysis and results that the ITU-R model overestimates rain attenuation at smaller rain rates and in the frequency range 10GHz to 150GHz, the ITU-R model performs well. It is found that for higher rain rates, specific attenuation values vary significantly at different locations and also different

from the ITU-R model. The results will be helpful in understanding rain attenuation variation and designing communication systems at EHF bands in the southern Indian regions. The study also indicates the need of actual measurement of DSD for different climatic zones.

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